SCIENTIFIC REPORT

Reference code: **COST-STSM-ECOST-STSM-ES1404-021115-067908**
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Period: 02/11/2015 to 06/11/2015

Introduction

The inland water bodies play an important role in the exchanges of energy, water and greenhouse gases between the surface and the atmosphere. As lakes cover an area of 4.2 million km^2, representing an area of more than 3% of Earth continental surface, an increasing concern in estimation of greenhouse gases exchanges between inland water bodies and the atmosphere has been developed in the last years. The eddy covariance (EC) method is the worldwide most common technique used to assess turbulent fluxes over all types of surface. EC method is a non-invasive technique, normally installed in a tower, and a less cost solution compared to the use of chambers. These turbulent fluxes, obtained with direct and continuous measurements, are important to estimate the exchanges of energy, water and greenhouse gases between the surface and the atmosphere. This technique has been focused, in the last years, in the estimation of CO_2 and CH_4 emissions by terrestrial and aquatic environments. The evaluation of CO_2 fluxes between lakes and the atmosphere, namely in melting and freezing periods, is an actual issue that requires new observational studies. The team from University of Helsinki is carrying EC measurements in boreal lakes since a long time and therefore has great experience in lake-atmosphere interaction either on ice free conditions (Mammarella et al., 2015) or over ice/snow covered lakes (Miettinen et al., 2015). On the other hand Évora University acquired the new Campbell Scientific's IRGASON Integrated Open-Path CO_2/H_2O Gas Analyzer and 3D Sonic Anemometer which as the unique feature of having the wind and gas measurements co-located in the same point avoiding the displacement correction required in other systems. This instrument was operating in the last summer in Alqueva reservoir, southeast of Portugal, in the framework of the ALEX project (FCT: EXPL/GEO-MET/1422/2013, www.alex2014.cge.uevora.pt). This large reservoir was object of a large variety of studies over the past years (Potes et al., 2012) and last year measurements of CO_2, as well as vapour, energy and momentum fluxes were performed with the new Campbell Scientific's IRGASON. The STSM proposed within the collaboration of Universities of Évora (Portugal) and Helsinki (Finland) has the main goal of having parallel measurements of heat and carbon dioxide turbulent fluxes over a boreal lake in Finland. In focus there will be two different systems of gas analyzers, a close-path from

Helsinki University and an open-path from Évora University, with the same output variables. Since this open-path is a new instrument, and few reports are available over lakes and reservoirs, this is a great opportunity to perform measurements over a boreal lake with either open-water or ice/snow cover. Moreover, a better understanding of the interactions between snow and the atmosphere requires improved measurements of energy, mass and momentum fluxes, which continue to have a high degree of uncertainty. In this regard, the testing of new equipment and performing inter-comparison experiments are important.

Eddy-Covariance

Regarding continuously measurements, air-water interface momentum, heat and mass (H_2O and CO_2) fluxes are obtained with the new Campbell Scientific's IRGASON Integrated Open-Path CO_2/H_2O Gas Analyzer and 3D Sonic Anemometer. The EC method allows for a better assessment of the water-air interactions. This technique uses high frequency measurements, typically 20 Hz, and 30 minutes averaged fluxes. Depending on the equipment some corrections need to be done in order to have corrected fluxes. In this case, three corrections are necessary due to instrument surface heating/cooling: first the three dimensional coordinate rotations, which result in zero vertical and transverse mean wind velocities, are applied to the covariances; second the correction of density fluctuations for thermal expansion and water vapour dilution according, and third the sonic temperature is corrected for water vapour. The corrected turbulent fluxes obtained are (in the following equations represents the rotated covariances between *a* and *b*):

Momentum flux:

Where is air density ; is water vapour density; is density of dry air ; where is gas constant for dry air; is the ratio of the molecular weight of dry air to water vapor and is the temperature corrected for water vapour: ; is sonic temperature in air, is Universal gas constant and is ambient pressure.

Sensible heat flux:

Where is specific heat of air (J Kg^{-1} K^{-1}). is gas constant for water vapour.

Latent heat flux:

The second term for water vapour dilution and the third for thermal expansion (both correction of density fluctuations for water vapour), where is the latent heat of vaporization (J g^{-1}).

Carbon dioxide flux:

Again, the second term for water vapour dilution and the third for thermal expansion (both correction of density fluctuations for water vapour), where is carbon dioxide density.

Installation

The measurement site was established where previous measurements were performed by Finnish team, located in a tip of narrow peninsula on lake Vanajavesi (61.133935°N ; 24.259119°E), offering very good conditions for eddy covariance flux measurements. The site presented a renewed wood platform with electric power where the equipment was installed (Figure 1). The Campbell Scientific's IRGASON Integrated Open-Path CO_2/H_2O Gas Analyzer and 3D Sonic Anemometer was installed at 2.5m height above the water surface and was oriented to 255º which are the prevailing wind direction in the site. The instrument from Helsinki University it's currently on maintenance and will be installed side-by-side once ready.
A phD student from Helsinki University, Maria Provenzale, will take care of the equipment maintenance once per month and also data transfer to University database. Data will be available for University of Évora through a new user on local server.

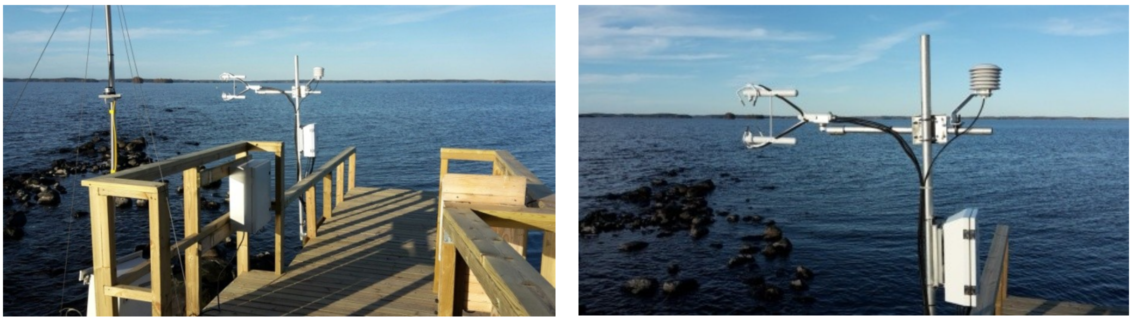

Figure 1: IRGASON assembled in the platform at lake Vanajavesi, Finland. (61.133935°N ; 24.259119°E)

Data

Both equipments should be operating synchronized until the ice-break period in the spring, covering open-water and ice/snow periods. The output fluxes will be subject of correction, some of them described above, some of them common for both systems and some specific for one system in case. These fluxes will be object of an inter-comparison study, point-by-point (30 minutes) and daily/monthly averages. The fluxes will be also related with lake surface state, wind speed and direction and temperature. Special attention will be give to a spectroscopic correction for the open-path gas analyser of IRGASON due to a possible overestimation of CO_2 uptake during periods with high positive sensible heat fluxes (Bogoev et al., 2015).

References

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